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HEARING CONSERVATION: INTENSE ACOUSTIC STIMULATION  
AND NOISE SUSCEPTIBILITY IN THE MILITARY ENVIRONMENT.

9 Final Comprehensive Report. 1 Oct 71-31 Mar

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HEARING CONSERVATION: INTENSE ACOUSTIC STIMULATION  
AND NOISE SUSCEPTIBILITY IN THE MILITARY ENVIRONMENT

Final Report Submitted to the  
U.S. Army Medical Research and Development Command

OVERVIEW

TYPE OF STUDY:

Definitive, based on experimental and survey techniques.

→ The TECHNICAL OBJECTIVES of this study were: (1)

- I. Assessment of current hazards to hearing and of current hearing conservation practices in the field. (2)
- II. Resolution of certain questions regarding past studies of temporary threshold shift; (3)
- III. Determination of the hearing capacities of those currently in the military or likely to be, comparison of those capacities with those of analogous groups in years past, and assessment of the practical significance of any changes observed; (4)
- IV. Measurements of changes in auditory characteristics other than absolute intensive threshold, following noise exposure; and (5)
- V. Development of indices of susceptibility to permanent hearing loss.

↑

HYPOTHESES:

- I. There will be changes in either or both the shape and the slope of the recovery curves that follow noise exposure, and these changes will be characteristically different for different acoustic stimuli and different individuals as severity of noise exposure is increased.
- II. For intermittent exposures in which intensity of the acoustic stimulus fluctuates between two or more values, there may be certain critical intensities of the less intense stimulus below which the threshold shift is independent of the intensity of the lower stimulus, and this critical intensity may vary as a function of the intensity of the more intense stimulus.

- III. For impulsive noise, a temporary threshold shift (TTS) produced by more closely spaced impulses may have a recovery function more like that of continuous noise than one produced by more widely spaced impulses.
- IV. Ears of those currently of military age exhibit more hearing loss than was typical 10 to 20 years ago.
- ✓ V. Certain measurements of the above (hearing level, amount of threshold shift, severity of noise exposure required to produce changes in the shape of the curve, and recovery from temporary threshold shift) may be related to susceptibility to permanent hearing loss.

Since the proposal was terminated at the end of its second year rather than being carried out over 5 years as proposed, it was not possible to conduct research relevant to all the above hypotheses. Data relevant to hypotheses I, IV, and V were gathered, and the findings will be discussed.

### Abstract

This is a Final Report for Contract No. DADA-17-72-C-2039, "Hearing Conservation: Intense Acoustic Stimulation and Noise Susceptibility in the Military Environment," between the University of Louisville Foundation, Inc., and the U.S. Army Medical Research and Development Command. It summarizes seven investigations, which were conducted and analyzed between October 1, 1971, when the contract was initiated, and March 31, 1974, when it was terminated. Detailed descriptions of some of these investigations have been issued as technical reports and journal articles, which are cited in the body of the report.

## 1. Field Studies on Conservation of Hearing

One of our purposes in carrying on research in this area was to determine whether recent recruits are inferior in auditory acuity to those encountered typically in the past. It was also our intent to determine whether accepted hearing conservation practices are being followed, whether there are temporary losses, indicative of significant hazard, and whether it is possible to develop a questionnaire which would allow field screening for potential hearing loss.

### 1.1 Auditory Acuity of Military Personnel at Different Stages in Military Training in Relation to Responses on a Questionnaire

This research has been described in detail as Technical Report 73-2, "Assessment of Hazard Posed by Training to Military Personnel Wearing Ear Protection and its Relation to Questionnaire Responses," by Michel Loeb, Paul D. Cameron, George A. Luz, Sheldon Luz, and Sharon L. Vanderhei. The following is a brief description of this experiment:

Temporary hearing loss following small arms fire was monitored for a group of trainees at a U.S. Army post. Audiograms were also taken for another group, and questionnaire responses were elicited regarding such matters as perceived quality, difficulty in hearing and communicating in noisy situations, and use of protective devices. Generally it appeared that trainees' hearing levels were within acceptable limits and that the temporary shifts after firing, while significant, were not excessive. There was a small but statistically significant hearing loss within the first eight weeks of training, and hearing levels and loss in training were related to responses on certain items of the questionnaire. The research has been submitted for publication in the Journal of Auditory Research.

### 1.2 A Comparison of Auditory Acuity of Drill Instructors With that of Basic Trainees and Its Relation to Observed Use of Aural Protectors

This research is described in detail in Technical Report 73-1, "Assessment of Auditory Acuity, Ear Protection, and Prediction of Hearing Loss in Military Personnel," by Michel Loeb, George A. Luz, Dennis Sheidler, and Sharon L. Vanderhei. The following is a brief description of this experiment:

It was suggested that it might be possible to predict hearing levels of Army drill instructors in the basis of single observations as to whether they were or were not wearing plugs. Although the data were in the predicted direction, differences between wearers and non-wearers of plugs, though appreciable, were not statistically significant. It also was observed that the drill instructors' hearing was considerably (and significantly) poorer than that of new trainees.

## 2. Laboratory Studies of Temporary Threshold Shift.

### 2.1 Relationship Between TTS and PTS in Animals

This research has been described in detail as Technical Report 74-1, "Audiometry in the Guinea Pig," by Stephen Crockett.

The following is a brief description of this experiment:

The guinea pig, like its more costly relative the chinchilla, has been widely utilized in anatomical and electrophysiological studies of the normal and pathologically altered auditory system. However, attempts to assess hearing in this species through behavioral audiometric techniques have met with limited success. One notable exception to this tradition is the "shiver audiometric" procedure originated by Anderson and Wedenberg (1965). The report describes the technique, critical variables, and limitations associated with its use, and modifications to enable automatic data recording and reduction. The audibility curve and its reliability obtained through shiver audiometry on a normal guinea pig population are presented and compared with those derived from other techniques.

While present work indicates that good correspondence between behavioral (shivering) and electrophysiological (evoked potential) measures was obtained, it appears that the effort involved in the behavioral determination is too great to make it a practical technique. The investigation in this area is continuing on our own funds: only EP measures are being taken. (Early work on this was presented at the May, 1973 meeting of the Acoustical Society of America in New York City; the abstract was published in the Spring 1974, Vol. 55, Supplement of the Journal of the Acoustical Society of America.)

### 2.2 Relationship Between TTS and PTS in Humans (Michel Loeb, Sharon L. Vanderhel and Bill R. Brown)

The following is a brief description of this experiment:

The purpose of this study was to induce TTS in humans and to determine whether there would be a relationship between any parameters relating to TTS--e.g., amount, curve shape, recovery time, etc. and amount of TTS. It originally was planned that military personnel would be used as Ss, since their work is such that some traumatic hearing loss might be expected. However it developed that following up such individuals did not prove feasible. We then decided to use ROTC personnel at the University of Louisville and follow them for four years.

A survey comparing HIs of freshman and senior ROTC cadets indicated that freshman ROTC cadets had thresholds as much as 7 dB lower at upper frequencies than those of non-ROTC freshmen. HIs of senior ROTC students were almost the same as those of non-ROTC seniors. The interaction

of status (ROTC or non-ROTC), college class, and frequency was statistically significant ( $p < 0.001$ ). It appears, then, that though ROTC cadets were somewhat more acute than other students at the beginning of their college careers, they were not substantially more so in their senior years.

These data suggested that it would be feasible to expose ROTC students to noise in gradually increasing increments until a criterion shift was attained and then correlate the parameters associated with these shifts with degrees of permanent loss incurred over four years. When it was learned that the contract would be terminated at the end of two rather than five years, it was considered that a measurable loss might be noted after one ROTC cruise. Accordingly 12 ROTC and 6 non-ROTC students were exposed on separate days to increasing durations of octave band noise centered at 1 KHz until a criterion TTS (20 dB TTS<sub>2</sub> at 4 KHz, 15 at 3 KHz, or 10 at 1 KHz) was obtained; then these were rechecked in the Fall (September or October). Further details will not be given, as nothing approaching a measurable statistically significant loss following the summer cruise occurred. It is evident that a study of this kind should not be undertaken unless Ss can be observed over a longer period--probably three or four years. There is no assurance then that we can predict the losses, but obviously we cannot if the period is too short for losses to occur.

### 2.3 Experiments on the Relationship Between Extent of TTS and Form of Recovery Curve (Michel Loeb, Sharon L. Vanderhei, and Ted Sommers)

Ward (1963) has reported that TTSs less than 40 dB are followed by recoveries of threshold which are linear in log time, while larger TTSs (say, exceeding 50 dB) are characterized by a period of no recovery, followed by a recovery linear in time. The purpose of our experiment was to replicate his findings and delimit more precisely the point at which this change in form occurred.

Ten Ss were run in this experiment. Each S was exposed to 103 dB of octave band noise centered at 1,000 Hz. Thresholds were tested before each exposure and afterwards typically at 3 and 4 KHz. Post-exposure thresholds were taken at 2 minutes (one only), 4, 8, 16, 32, 64, 128, and sometimes further multiples until recovery to within 5 dB occurred.

Generally, testing was performed on a Grason-Stadler Bekesy-type audiometer. Testing was continued until TTS at 2 minutes exceeded 35 dB. It was found that so long as TTS was less than 40 dB, recovery was continuous and linear in log time. At higher levels it developed that recovery could be continuous and linear in log time or delayed (non-occurring for 30 - 120 minutes), then linear in log time or diphasic (i.e., consisting of two segments, linear in log time).



Whether these different types of curves really reflect different processes or not is not known. We do not even know that they do not reflect fluctuations in criterion for responding and that they might not vary from time to time given the same magnitude of shift in the same individual. The fact that the variations typically appear at high values of TTS makes this hypothesis unlikely to be true, but it may be that a greater magnitude of shift allows for a greater fluctuation. Further studies should be run involving repetition of the original exposure.

#### 2.4 Test-Retest Audiometric Reliability in Unselected Samples of Army Personnel.

This research has been described in detail in U.S. Army Medical Research Laboratory Report 1075, "Test-Retest Audiometric Reliability in Unselected Samples of Army Personnel," by George A. Luz, and Michel Loeb. The following is a brief description of this experiment:

The objective of this research was to determine audiometric reliability in two unselected samples of Army personnel. A mobile audiometric laboratory was used to test and retest the hearing of protected basic combat trainees before and after firing a machine gun and of tank mechanics before and after a weekend of rest. It was found that audiometric reliability was high in both groups, leading to the conclusion that a previous report of low audiometric reliability in individuals tested before and after basic combat training-advanced individual training should probably be interpreted as resulting from permanent, noise-induced changes in auditory sensitivity.

#### 2.5 Changes in Hearing Other Than Absolute Intensive Threshold (Michel Loeb and Dennis Holding)

It was initially contemplated that we would investigate after-effects of noise on factors other than threshold, including masking by noise or other temporally contiguous stimuli. While some preliminary data on this were gathered, which have been written up for publication, this phase was discontinued. Reports of early experiments have been published in two articles ("Masking" Versus Interference in Pitch Perception, Journal of Auditory Research, (12), 247-254, 1972 by Dennis Holding, Michel Loeb, and Delmar Yoder; and Delayed Interference in Pitch Judgments, by Michel Loeb and Dennis Holding, Journal of Auditory Research, in press.

## Footnotes

<sup>1</sup>Now at St. Marys College of Maryland, St. Marys, MD 20686

<sup>2</sup>Ward, W. D., "Auditory Fatigue and Masking" in J. Jerger (Ed.), Modern Developments in Audiology, New York: Academic Press, 240-286.

<sup>3</sup>Anderson, H. & Wedenberg, C. A new method for hearing test in the guinea pig, Acta Otolaryngologica, 1965, 60, 375.

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